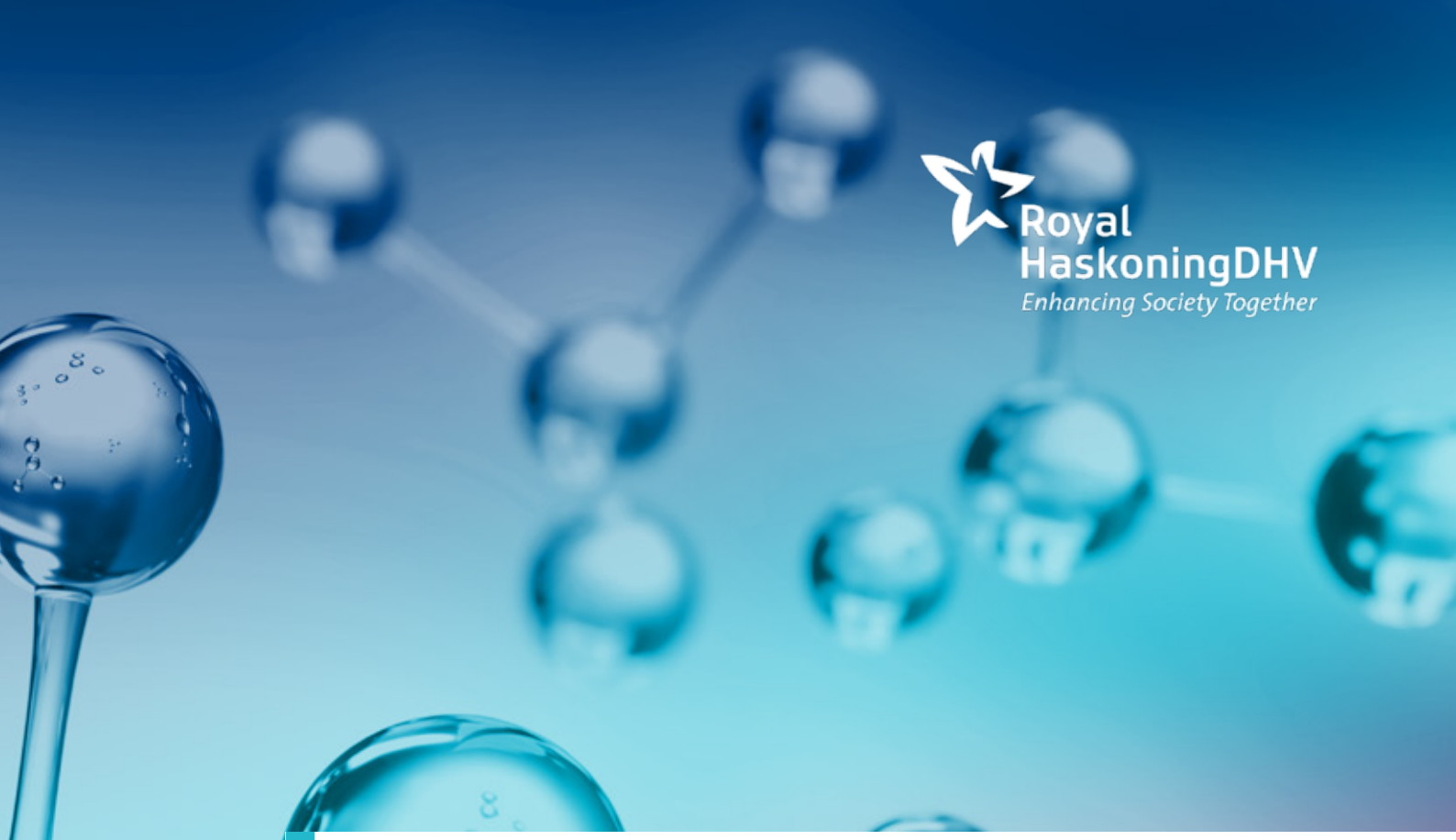

Royal HaskoningDHV
Enhancing Society Together

CURRICULUM FRAMEWORK FOR ACADEMIA AND VOCATIONAL TRAINING INSTITUTES

with Courses for the Chemical, Pharmaceutical, Rubber and Plastics Sectors

FECCIA CEC EUROPEAN MANAGERS

ECEG European Chemical Employers Group

ledarna SVERIGES CHEFSORGANISATION

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1 Introduction

This document provides a curriculum framework of digital skills, supporting transversal and social skills to make sure that professionals are prepared for the digital transformation of the chemical, pharmaceutical, rubber, and plastics sector. This framework can be used at vocational education and training (VET) and academia to make sure that the new generation of young people who are preparing for a career in these sectors possess the required advanced digital skills and qualifications. This framework has been derived from desk research and a number of workshops with Industry employers, workers and managers during spring 2022. With a representation from the various sectors. We present a framework as digital skills for curricula- and final-qualifications for students that must be acquired during the education besides the general program. Some of these qualifications are new for most education institutes and are highlighted in the framework. The digital technology that is associated with each skill is changing continuously: e.g. new social media platforms keep emerging, and new sensors are entering the market, this framework is therefore at a more generic level and does not describe specific digital technologies We advise to align the curriculum framework with the ECTN frameworks

We present the Digital Skills framework for the sector specific jobs and tasks, the differences across the sectors are not large, however in pharma the usage of digital technologies seems already more advanced of which the in-silico research is an illustrative example.

Digital skilled lecturers/professors are a prerequisite to transfer knowledge and a train-the-trainer approach is a best practice to enlarge the learning capabilities of a sector. To be able to educate and acquire new skills facilities are needed like data labs to acquire skills.

Building an eco-system with industry (cases, expressed needs, hybrid teachers) is a best practice to align industrial needs with curriculum, upskill both trainers and professionals. The learning community model integrates learning, innovation and work at one centre is a concept that shows it value at the moment.

Adaptivity has been indicated as the main supporting skill to acquire to be able to learn how to unlearn and respond to the fast changing digital technologies. This also asks for a process to keep aligning courses to the needs of the industry, since the current digital skills framework must be updated soon due to the continuous emerging of new technologies.

Cyber security and awareness of digital vulnerability needs more attention to be able to make informed decisions on adopting new digital technologies.

2 The digital transformation

The digitization of manufacturing is gradually transforming the maintenance function from analogue, and paper based towards digital and sensor based. This offers on the one hand many opportunities for e.g. predictive maintenance, but on the other hand, it requires many new skills. Partly, this digitization helps to improve registrations of failures, asset condition and usage by making the registration less dependent on human input. However, expert knowledge and knowledge management remain key: more specialists are required for collecting and analysing specific data. (Tiddens, 2018)

Smart Maintenance relies on the comprehensive collection of data, and the capacity for remote monitoring to enable a constantly updated information stream, available at any time and in any place. This leads to guided predictive maintenance and optimized repair strategies. Machines with deep learning capacity not only analyze past and present performance but can also offer valuable insights and diagnostics for machines and their components.

Digital platform in logistics creates visibility of inventory positions, movement of goods, delivery performance and compliancy with respect to safety processes. (Gmür, 2018)

In pharmaceutical logistics, digitalization initiatives are currently mainly focused on tracking & tracing practices. New shipment regulations (GDP) are forcing companies to place greater emphasis not only on how they track and trace their shipments, but also on temperature control during shipment. Smart technologies and centralized cloud platforms provide better and more comprehensive means to comply with these requirements. In addition to track & trace, pharmaceutical logistics is also showing a strong interest in serialization.

Many pharmaceutical companies are looking into opportunities to implement central supply chain control towers and the underlying IT solutions as a means not only to gain more visibility into their supply chain, but above all to give them better proactive control over their shipments and supply chain execution.

Internet of Things (IoT) leads to new system architectures where open standards play a significant role. Through better connectivity, information will be more easily available, which could result in integration of previously isolated functions and will become more closely integrated. Here modelling at the right level of fidelity will be key. It can be expected that the importance of optimization will increase. Another trend is the fact that handheld sensors and wearable devices will enter the shopfloor

Digital technologies are changing the way research and innovation is being performed: examples are in silico research for items like drug candidate screening, cell simulations, as well as the use of digital twinning to predict impact of new technologies and the usage of technology scouting using artificial intelligence.

New ways of data driven chemistry and research are emerging. Part of a data driven research and innovation strategy is to collect, aggregate and analyse all available research data and provide data to all relevant workers (internal knowledge management system).

3 Master curriculum best practices

To reuse available open education resources, they must be clearly described and tagged using standardized skills. From the description it has to be clear what the intended level of the course material is (academic, vocational etc) It helps when education resources are small so that can be compiled together to a new course.

English is the defector standard of educational resources that must be used in diverse student populations, or which is intended to be published as open educational resource. The curriculum typically is updated every 3 years by leading universities, this allows to include new digital technologies.

The cooperation with industry is vital to stay up to date with the needs of industry. Learning Communities including the link with SME's (internships e.g.) can help to create a common basis on digital skills. It is common practice to offer students entrance tests and courses on basic digital skills. This can be done across disciplines and with project assignments or online courses. One set of entrance courses regular mentioned by knowledge institutes is the Khan academy.[1] A best practice is the usage of cross disciplinary digital project weeks in which students work on industrial challenges to be solved with digital technologies: this enlarges both communication as well as digital skills set. Leading universities all use online learning environments (LMS systems) and tend to apply a flipped classroom concept that allow to focus on how information can be used. The usage of online or e-exams is increasing, and new technologies are used for candidate authentication (voice, image recognition) and to monitor the candidate via webcam for suspicious behavior.

A good example of the impact of Virtual reality in education is the usage of Virtual Reality to experience the structure of proteins with multiple students at the same time. With a VR headset (Google Cardboard compatible) and a smartphone, everyone can experience the 3D chemical structure from the Protein Data Bank. Another example is the usage of gamification and 3d-modelling to learn about protein folding

Digital twinning is starting to be used for training as a method to deal with normal operation or maintenance but also how to react to anomalies and incidents in a realistic and safe manner. Related to this trend is the usage of e-labs to provide e-learning and real scientific experiments and data analysis tools, reducing lab costs and creating a 24/7 accessible test environment for training.

1 https://www.khanacademy.org/

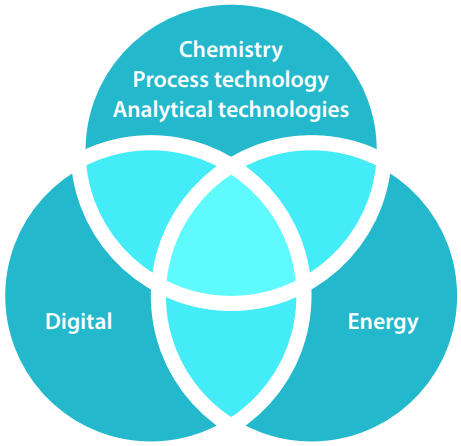
4 Skills sets

The skills domain of the professional in chemistry can be considered to deal with the traditional skill domain areas for chemistry, process technology and analytical technologies, extended with knowledge on Digital technologies and Energy or Sustainability skills. IT professionals will cover the green lower left part, energy specialist the green lower right part. This framework deals with the blue left upper part and the black part that describes which skills a professional in industry much has about the digital technologies.

Please note that in the proposed learning activities of the European Chemistry Thematic Network Association (ECTN) framework there's limited focus on digital learning approaches. With the current possibilities of online learnings, virtual reality, simulations, etc, we see room for innovation of the learning approach as well.

During their degree programme students should develop a realisation of the importance of chemistry in the world around us and of its possibilities for helping to solve problems for which mankind needs to develop solutions if it is to survive. It is thus vital that teachers do not stress only the academic side of the subject, but also present material relevant to topics such as:

- Chemistry and industry
- Chemistry and the environment
- The economic importance of chemistry
- Chemistry and energy, climate change and food production
- Chemistry and biology
- Chemistry and medicine
- Social aspects of chemistry
- Regulatory framework



5 Curriculum framework

Based on the needs of industry we propose the following expected learnings for curriculum framework for the academic and vocational institutes that provide a course for maintenance, operations or logistic engineering. This consists of a number of applied data science skills from the Edison Data Science Framework (EDSF)[2] concerning domain knowledge expertise and data management and governance skills.

2 Y.Demchenko e.a. 2018 EDISON Data Science Framework: Part 1. Data Science Competence Framework (CF-DS) Release 3

NEW SKILLS THAT HAVE TO BE INCORPORATED IN ACADEMIA BASED ON EDSF AND EXTRA AS INDICATED BY INDUSTRY AND KNOWLEDGE INSTITUTES.	Maintenance	Operations	Logistics	R&D
Use appropriate data analytics and statistical techniques on available data to discover new relations and deliver insights into research problem or organizational processes and support decision-making.	X	X	X	X
Able to interact with digital systems using various types of interfaces including service and industrial robots using various interfaces like voice based or gestured based.	X	X	X	X
Effectively use a variety of data analytics techniques, such as Machine Learning (including supervised, unsupervised, semisupervised learning), Data Mining, Prescriptive and Predictive Analytics, for complex data analysis through the whole data lifecycle.	X	X	X	X
Apply designated quantitative techniques, including statistics, time series analysis, optimization, and simulation to deploy appropriate models for analysis and prediction.	X	X	X	X
Identify, extract, and pull together available and pertinent heterogeneous data, including modern data sources such as social media data, open data, governmental data, verify data quality.	X	X	X	X
Understand and use different performance and accuracy metrics for model validation in analytics projects, hypothesis testing, and information retrieval.	X	X	X	X
Develop required data analytics for organizational tasks, integrate data analytics and processing applications into organization workflow and business processes to enable agile decision making.	X	X	X	X
Visualise results of data analysis, design dashboards and use storytelling methods.	X	X	X	X
Analyse information needs, assess existing data and suggest/identify new data required for specific business context to achieve organizational goal, including using social network and open data sources.	X	X	X	X
Expert skills in risks and regulations in relation to unsafe interaction with digital tools and data.	X	X	X	X
Expert skills in communicating insights in different (digital) format and system.	X	X	X	X
Knowledgeable about available sensor technology and the upcoming trends like wearable censoring.	X	X	X	X
Basic understanding of AI, the different type of Machine Learning algorithms and neural networks, without relying heavily on coding.	X	X	X	X
…	…	…	…	…

…	…	…	…	…
Ability to work with maintenance management systems.	X			
Ability to work with supply chain management and order systems.			X	X
Ability to work along co-bots.	X	X		
Ability to work with energy monitoring systems and analyse data to optimize usage.		X		
Able to work with distributed control systems and knowledgeable with its elements and global architecture.		X		X
Ability to work with Inventory and Warehouse systems.	X		X	
Understands the tagging and tracing possibilities like QR codes, RFID technologies, barcodes.			X	
Able to work with Tracking and Tracing solutions.			X	X
Able to use the data provided by supply chain control towers.				X
Operationalise fuzzy concepts to enable key performance indicators measurement to validate the business analysis, identify and assess potential challenges.				X
Ability to developing creative formats, including multimedia, and programming.	X	X	X	X
SUPPORTING TRANSVERSAL AND SOCIAL SKILLS RELATED WITH THE DIGITAL TRANSFORMATION	**Maintenance**	**Operations**	**Logistics**	**R&D**
Adaptivity, learning agility and readiness for change mainly as result of the fast-changing technology context.	X	X	X	X
Skills on intercultural competences as result of the growing diversity in teams.	X	X	X	X
Ability to maintain relationships with internal and external stakeholders.	X	X	X	X
Ability to cooperate and communicate with non-experts and professionals of other fields.	X	X	X	X
Ability to cooperate in virtual teams.				
Ability for Networking and collaborating through digital channel.				
Ability for Interacting with and participating in communities and networks.				
Problem solving skills and awareness of different (digital) problem solving techniques and the ability to select appropriate approach.	X	X	X	X
Ethical and safety skills with the ability to protecting self from online fraud, threats, Protecting data and digital identities and Ethical awareness.	X	X	X	X
Computational thinking.	X	X	X	X

Imprint

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